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Bedrock Well Installation and Geophysical Evaluation
Union Chemical Company Site
214 Main Street
South Hope, Maine

Submitted to:
Maine Department of Environmental Protection

April 30, 2004

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April 30, 2004

Mr. Terry Connelly
United States Environmental Protection Agency
Region I
One Congress Street, Suite 1100 (HBT)
Boston, MA 02114-2023

Ms. Rebecca Hewett
Maine Department of Environmental Protection
State House Station 17
Augusta, ME 04333

Re: Bedrock Well Installation and Geophysical Evaluation
Union Chemical Company Site
214 Main Street
South Hope, Maine

Dear Mr. Connelly and Ms. Hewett:

At the request of the United States Environmental Protection Agency (USEPA) and the Maine Department of Environmental Protection (DEP), Rizzo Associates has prepared this report summarizing the installation and geophysical evaluation of a new deep bedrock well at the above-referenced property (the Site). This report also presents a summary of the installation of three replacement monitoring wells, including one screened in the shallow bedrock at the Site.

Please contact the undersigned if you have any questions.

Very truly yours,

William C. Phelps
Senior Project Geologist

Raymond C Johnson for Robert J. Ankstitus, P.E.
Senior Project Manager

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1.0 Introduction

This report presents the results of a bedrock evaluation program implemented at the Site by UCC RD/RA Trust (Trust) at the request of the United States Environmental Protection Agency (USEPA) and the Maine Department of Environmental Protection (DEP). This program included: the installation of a deep bedrock boring, the geophysical evaluation of the deep bedrock boring and one existing bedrock well (ITW), and installation of a nested monitoring well couplet within the new bedrock boring. Additional activities conducted during this investigation included the installation of replacement monitoring wells for the B-5 well triplet.

2.0 Background

Previous environmental investigations at the Site have identified low concentrations of volatile organic compounds (VOCs) in bedrock monitoring wells at the Site. The majority of the bedrock monitoring wells installed as part of these investigations have focused on the shallow bedrock (i.e. within 10 to 20 feet of the bedrock surface), while only a few have been advanced deeper than 100 feet into the bedrock. A review of the groundwater data collected from the deeper monitoring wells indicated that an additional deep bedrock monitoring point was required on the downgradient portion of the Site to further delineate the extent of impacts to the deep bedrock unit.

The Trust, Rizzo Associates, EPA and DEP personnel visited the Site in October 2003 to identify the location of the new bedrock boring/well, taking into consideration the existing monitoring well network, the limits of the property, and Site access. Figure 1 shows the location chosen and ultimately utilized for the new deep bedrock boring/well installation. Concurrently, the EPA and DEP indicated that the B-5 monitoring well couplet, located adjacent to Quiggle Brook, needed to be replaced. Replacement was required since obstructions in the small diameter (3/4") well casings did not permit the collection of groundwater samples from these wells.

3.0 Deep Bedrock Boring Installation

Rizzo Associates engaged Bowie Brothers Well Drilling of Farmingdale, Maine to advance a 6-inch diameter bedrock boring at the Site. Initially, drilling activities were scheduled to begin on October 27, 2003; however, persistent heavy rain and soft ground conditions at the Site required the construction of a temporary roadway to the drilling location. This work was completed the same day and the deep bedrock boring was advanced on October 28, 2003.

3.1 Bedrock Boring Advancement

Boring advancement was performed by Bowie using a Reichdrill T690W air-rotary drilling rig. Once the rig was mobilized to the drilling site and the drillers completed tooling the rig, a 8-inch diameter pilot boring was advanced to refusal using mud-rotary drilling techniques. Refusal on bedrock was reportedly encountered at a depth of 47 feet below the ground surface. Once the bedrock was encountered, the pilot boring was advanced an additional 5 feet into the top of the rock (total depth of 52 feet bgs). A six-inch diameter steel casing was installed in the pilot boring and grouted in place using a cement/bentonite grout mixture. The remainder of the boring was advanced using air-rotary drilling techniques to a depth of 302 feet below the top of the casing (btoc).

3.2 Bedrock Lithology

During the advancement, the rock chips that were evacuated from the casing were logged by the DEP at approximately one-foot intervals. A copy of the Boring Log prepared by the DEP is included as Appendix B. In general, the lithology logged during the installation of the boring was consistent with other bedrock logs from the general area. Based on the rock chips, the bedrock encountered at the drilling Site was identified as predominantly fine-grained gneiss or high grade schist that had been extensively intruded by granite and granite pegmatite. Large zones of pegmatite intrusion were encountered at depths of 170 to 200 feet and 250 to 277 feet btoc.

During boring advancement, the driller reported possible fracture zones at depths of 52, 69, 117, 136, 140 and 142 feet btoc. Evidence of weathered rock (iron-stained pegmatite chips) was observed at a depth of 81 feet btoc.

3.3 Boring Development

At the conclusion of the drilling activities, the driller allowed the boring to stabilize for approximately 10 minutes, then pressurized the casing using air from the drilling rig to purge the standing water in the casing to "rate" the well. According to the driller, a production rate of approximately 2 gpm was achieved. A "sweet" solvent was odor was noted at the time the initial purging of the well was performed. Headspace screening of a sample of the purge water produced an elevated PID response; however, this response was likely attributed to the water vapor causing interference with the instrument. At the conclusion of the development activities a well cover was bolted to the top of the casing.

4.0 Replacement Monitoring Well Installation

The Trust and Rizzo Associates engaged Maine Test Boring of Brewer, Maine to perform the installation of replacement monitoring wells for the B-5 well series. Installation of these wells was performed between October 27 and 29, 2003 under the supervision of a Rizzo Associates geologist.

Replacement wells were advanced approximately 10 feet north of the existing B-5 series well triplet using a track-mounted ATV drilling rig and included the installation of two overburden and one bedrock monitoring wells. Initially, hollow and solid-stem augers were utilized to attempt the boring advancement; however, due to extremely difficult drilling conditions (large boulders and dense, clay-rich till), a combination of augers and drive casing were used to complete the borings in the overburden. Since these wells were installed in close proximity to the original wells, overburden soil samples were not collected during drilling. Well completion reports prepared by Rizzo Associates are included in Appendix B.

The intent was to screen the new wells over the same intervals as those being replaced. The shallow replacement well, B-5E-S, was screened over the same interval as the original shallow well, B-5B-S. However, the original intermediate well (B-5B-S) and original bedrock well (B-5B-I) were completed using only two-foot sections of well screen. In an attempt to provide additional recharge for sampling events, the intermediate and bedrock replacement wells were completed using 5-foot sections of well screen. In general, the screened intervals in the replacement wells included the intervals for the original wells.

4.1 Shallow Overburden Replacement Well

Replacement boring/well B-5E-S was installed to a depth of 10 feet bgs and was completed with a 5 foot section of 2-inch diameter, 0.010-inch machine slotted PVC well screen set at the bottom of the boring and 5 feet of solid PVC riser. This well was installed as a replacement to existing well B-5B-S which was also screened from 5 to 10 feet bgs.

4.2 Intermediate Overburden Replacement Well

Replacement boring/well B-5D-I was installed to a depth of 36 feet bgs and was completed with a 5 foot section of 2-inch diameter, 0.010-inch machine slotted PVC well screen set at the bottom of the boring. The annular space around the well screen was backfilled with filter sand and the remainder was grouted using a cement/bentonite slurry. This well was installed as a replacement to existing well B-5B-I, which was completed with only two feet of screen, set from 35 to 36 feet bgs. Replacement well B-5D-I was completed with 5 feet of screen (set at 31 to 36 feet bgs) in an attempt to provide additional recharge during sample collection activities.

4.3 Shallow Bedrock Replacement Well

Replacement boring/well B-5C-D was installed to a depth of 73 feet bgs. Bedrock at this location was encountered at a depth of approximately 63 feet bgs. Bedrock at this location was cored in three intervals using a 3-inch diameter, wire-line HQ core barrel. The first core was from 63 to 66 feet, the second core was from 66 to 69 feet and the final core was from 69 to 73 feet. The limited core intervals were primarily due to the fractured nature of the shallow bedrock, which would break apart during drilling, jamming the core barrel. The following paragraphs present a summary of observations make of the cores:

Core #1 (63-66 feet). Approximately 2.8 feet of the 3.0 foot core was recovered in the core barrel, for a recovery of approximately 93%. There were approximately 4 core sections that were at least 4 inches in length, yielding a Rock Quality Designation (RQD) of 63%. The majority of the fractures in the cores appeared to be mechanical and are attributed to the difficult drilling conditions. Two weathered, steeply dipping fractures were observed at depths of 64 and 66 feet. The core sections were predominately a gray-green, medium to coarse-grained granite pegmatite. Minerals evident in the core samples included zones of abundant mica and iron pyrite.

Core #2 (66 to 69 feet). Approximately 2.9 feet of this 3 foot core run were retrieved, yielding a recovery of 97%. Only three of the core sections had lengths of 4 or more inches, yielding an RQD of 53%. As with the previous core, the majority of the breaks in the core were fresh and are attributed to drilling. Several steeply dipping, weathered fractures were noted in the core from 67 to 68 feet. The core section from 68 to 69 feet was comprised of a 0.9 foot continuous section of rock. The lithology of the sample was a medium to coarse grained pegmatite similar to the previous core to a depth of approximately 67 feet bgs. Below the 67 foot depth the rock type changed abruptly from granite/pegmatite to a dark gray, fine grained gneiss. This change in the rock coincides with the zone of weathering observed in the core at 67 to 68 feet bgs, and may represent groundwater flow along this geological contact.

Core #3 (69 to 73 feet). A total of 3.4 feet of this 4-foot core run were retrieved, yielding a recovery of 85%. Of the core recovered, a total of six sections were 4-inches or greater in length, yielding an RQD of 74%. All of the breaks in the core appeared to be fresh, mechanical breaks attributed to the drilling process. No evidence of weathering was observed in any of the sections. The rock type was generally a gray fine to medium-grained, massive, gneiss.

B-5C-D was completed as a 2-inch diameter monitoring well with 5 feet of 2-inch diameter PVC well screen. The original bedrock well at this location was completed with only two feet of screen set at 66 to 68 feet bgs. Based on observations made during the drilling activities and the desire to provide additional recharge to the well during sampling, five feet of screen, set from 68 to 73 feet bgs, were utilized in B-5C-D. The remainder of the well was constructed using 2-inch diameter solid PVC riser. The annular space around the well was backfilled with graded filter sand to a point approximately one foot above the top of the well screen. A bentonite chip seal was set from 67 to 63 feet (the top of the bedrock). The remaining annular space was grouted using a cement/bentonite slurry placed with a tremie pipe.

5.0 Geophysical Investigation

The Trust and Rizzo Associates engaged Hager GeoScience, Inc. (Hager) to perform a geophysical evaluation of the newly installed bedrock boring and existing deep bedrock well (ITW). The primary focus of this investigation was to identify potential water bearing fractures/zones in the new bedrock boring and to identify possible screened intervals for the future monitoring well cluster at that location. Existing deep bedrock well ITW was also evaluated in an attempt to correlate the bedrock fracture occurrence and orientation across the Site. This work was completed November 12-14, 2003.

5.1 Implementation Approach

After mobilization and calibration of the instrumentation, the boring caliper log was run while withdrawing the instrument from the boring. The polyelectric log, which included the normal resistivity, single point resistance, spontaneous potential, natural gamma, fluid temperature and fluid resistivity was also run from the bottom up. Once the polyeletric log was completed, the acoustic televiewer (ATV) was lowered to the bottom of the hole and the boring was logged from the bottom up. The heat pulse flow meter (HPFM) was run after the ATV, and logging was performed to evaluate ambient conditions while the probe was lowered in the boring and under stressed conditions when the probe was being retracted. The television log was the final log run on each boring.

5.2 Results – New Bedrock Boring (NBW)

Logging of the new bedrock well was performed on November 12th and 13th, 2003. A copy of the Hager report is included as Appendix C. The results of the logging are summarized below.

Caliper Log – The two-point caliper log was run starting from the bottom of the borehole. Small "kicks" or changes in the diameter of the borehole were observed at the following depths/depth intervals: 62 to 68 feet, 75 feet, 81 to 85 feet, 97 feet, 168 feet, 173 to 177 feet and 228 feet btoc. Larger caliper variations were noted at 137 feet and 141 to 150 feet, with the largest observed increase in the diameter of the borehole of approximately 1 inch at 141 feet btoc.

ATV Log – As with the caliper log, the ATV log was run up the boring, beginning at approximately 300 feet btoc. The following table summarizes the most significant observations made during the logging with regard to bedrock fractures. All depth measurements are referenced to the surface.

Table 1 ATV Logging Summary - NBW

Depth (feet)	Comments
62 – 63	Low angle fracture observed
79 – 80	Large, high angle fracture
111 – 114	Set of small, but frequent fractures
115 - 117	Zone of small, low angle fracturing
124	Small fracture
136	Large ATV reflection, possible fracture zone
137 - 145	A few small fractures
157	Medium aperture, high angle fracture
168 – 175	Zone of fracturing or possible sheeting of borehole

188	Moderate aperture fracture possible
202	Small set of fractures
228 – 229	Large fracture possible

Heat Pulse Flow Meter – Two sets of readings were taken with the HPFM, ambient and stressed. Ambient readings were taken at specific intervals while the probe was being lowered from the surface. After the probe reached the bottom of the boring a submersible pump was installed in the boring and water was pumped out at a rate of approximately 0.5 gpm. Stressed HPFM readings were then collected as the probe was slowly removed from the boring. Stressed readings were collected at the same depth intervals as the ambient readings, and three readings were collected at each interval for reproducibility.

Ambient HPFM readings were collected at the following depths in the new bedrock well: 56, 63, 70, 90, 100, 130, 140, 150, 160, 170, 180, 220, 230, 240, 250 and 280 feet btoc. In general, no evidence of ambient flow in the borehole was evidenced by the HPFM data. Evidence of very slight (less than 0.01 gpm) upward flow was observed in the readings collected at the 130, 140 and 150 foot depths; however, the flow was inconsistent across the three readings collected at each depth and the data is therefore not considered significant.

Stressed readings were collected as the probe was withdrawn from the boring, at similar depths to those utilized during the ambient screening. No evidence of flow was evidenced by the HPFM at depths below 150 feet. Above that depth, HPFM readings increased from 0.05 gpm at the 140 foot depth to 0.34 gpm at the 50 foot depth. Graph #1 in Appendix D summarizes the HPFM results.

Polyelectric Logs – In general, the results of the polyelectric logs correlated with observations made during the installation of the boring and the caliper and ATV logs. A review of the resistance logs indicates that zones of low resistivity (115 to 175 feet and 280 and 300 feet) correlated well with the gneiss reported in the log for the boring prepared by DEP and zones of high or variable resistivity correlated with well with observations of pegmatite in the DEP log. In general, the fluid temperature in the boring increased with depth, with a total gain of approximately 1.0 degree centigrade at a depth of 300 feet. Fluid conductivity in the borehole appeared to vary, with a gradual increase from 50 to 110 feet btoc at which point it decreased gradually down to a depth of 210 feet btoc. The fluid conductivity then increased at a moderate rate from 210 to 240 feet then was steady to the bottom of the hole at 300 feet.

Television Log – The television log was run using a black and white downhole camera. However, due to the high turbidity of the water in the new boring, the TV log was terminated at a depth of 150 feet btoc. The following table summarizes observations that were made during the limited TV log:

Table 2 Television Log Comments - NBW

Depth (feet btoc)	Comments
117	Large possible fracture noted
125 – 128	Continuous steeply dipping, near vertical fracture
137	Evidence of foliation plane fracturing
139	Evidence of borehole breakout
150	End of TV log – visibility near zero

Data Evaluation and Correlation In their report, Hager indicated that discontinuities in the new bedrock well are predominately high angle fractures dipping N15-50E and S10-60W. Little evidence of NW or SE dipping discontinuities were identified by Hager in the logs. As part of their evaluation, Hager classified the discontinuities observed during the logging into three categories of "aperture potential" (high, moderate and low), with aperture potential representing the likelihood that the discontinuities identified in the logs represent actual open, possibly transmissive, fractures in the rock. The determination of aperture potential was made by Hager based on a comparative review of all the individual logs for each well. A review of the data, specifically the stereo plots included as Appendix A, indicates that a majority of the fractures classified by Hager as "high aperture potential" dip steeply to the southwest. Since this fracture set is classified with a high aperture potential, it is likely the primary pathway for groundwater flow within bedrock at this location. The data indicates that these fractures occur at a variety of depths and are not specific to certain intervals, as was observed in the previous rounds of logging conducted at the Site. Based on this data, groundwater flowing in a down-dip direction in these fractures has the potential to flow from B-8A-D to the newly installed bedrock well couplet, making it an acceptable downgradient bedrock monitoring point for contamination observed on the upper portion of the Site. A review of the data also supports the theory that fracture aperture and frequency decrease with depth. In general, the number of fractures with high aperture potential decreased with depth, with a majority of the fractures identified at depths below 260 feet classified as having a low to moderate aperture potential. At depths above 260 feet, the reported fracture aperture potential varied from high to low, with a greater numbers of discontinuities reported as having high aperture potential.

A review of the logs indicates that there is general correlation between the electrical resistivity logs and the lithology log prepared by the DEP. As was previously discussed, zones of high resistivity were generally observed at depths logged as pegmatite or pegmatite/granite and lower resistivity zones correlated with the intervals logged as gneiss. Based on the gradual changes in temperature and fluid resistivity, no specific correlation between changes in these parameters and identified fracture zones is noted in the data. Correlation between the ATV and caliper logs appeared to be good, as many of the potential fractures identified by the caliper log were also observed in the ATV log.

5.3 Results – ITW

Logging of ITW well was performed by Hager on November 14, 2003. A copy of the Hager report is included as Appendix D. The results of the logging are summarized below.

Caliper Log – The two-point caliper log was run starting from the bottom of the borehole (500 feet btoc). Small to moderately sized fractures were noted at depths of 26, 27.5, 471, and 498 feet btoc. Very small fractures were reported at depths of 51, 52, 100, 124, 147, 170, 181 and 185 feet btoc. Constrictions of the borehole were noted at depths of approximately 230, 250, 256 and 277 feet btoc, with a maximum decrease of approximately ½ inch in the borehole diameter observed at the 256 foot depth.

ATV Log – As with the caliper log, the ATV log was run up the boring, beginning at approximately 500 feet btoc. The observations made during the logging are summarized in the attached Table 3. All depth measurements are referenced to the top of casing.

Heat Pulse Flow Meter – Two sets of readings were taken with the HPFM, ambient and stressed. Ambient readings were taken at specific intervals while the probe was being lowered from the surface. After the probe reached the bottom of the boring a submersible pump was installed in the boring and water was pumped out at a rate of approximately 0.5 gpm. HPFM readings were then collected as the probe was slowly removed from the boring. Stressed readings were collected at the same depth intervals as the ambient readings, and three readings were collected at each interval for reproducibility.

Ambient HPFM readings were collected at the following depths in ITW: 22, 25, 35, 40, 50, 60, 70, 95, 144, 180, 210, 400, 475, and 490 feet btoc. In general, evidence of a very slight upward ambient flow (0.01 gpm) was observed in the first of three readings collected at sampled intervals above 400 feet. However, this flow was not reproducible across the three readings taken at each interval, and may represent drift in the instrument.

Stressed HPFM readings were collected as the probe was withdrawn from the boring, at depths of 490, 475, 400, 350, 210, 180, 144, 95, 70, 60, 50, 40, 35, 25, and 22 feet btoc. No evidence of flow was evidenced by the HPFM at depths below 95 feet btoc. Above that depth, HPFM readings increased from 0.06 gpm at the 95 foot depth to 0.37 gpm at the 40 and 35 foot depths. Graph #2 in Appendix D summarizes the HPFM results for ITW.

Polyelectric Logs – In a manner similar to that observed in the new bedrock well, zones of consistently high and consistently low resistivity were observed in the electric logs. However, ITW was not logged when it was installed, so no record of the rock types encountered during drilling is available for correlation. Zones of higher resistivity were observed at the following depth intervals: 30 to 50 feet, 70-95 feet, 115 to 280 feet, and 330 to 450 feet, with the remaining zones having low or highly variable resistivities. This variation is likely an indication in changes in lithology between the low resistivity gneiss and higher resistivity granite/pegmatite.

In general, the fluid temperature in the boring increased from approximately 9.5 degrees Centigrade at 22 feet btoc to approximately 11.25 degrees Centigrade at 500 feet btoc. Fluid resistivity in the borehole appeared to vary gradually, with a gradual increase from 22 to 245 feet btoc. The conductivity remained relatively constant from 245 feet to 370 feet btoc at which point it decreases rapidly between 370 and 400 feet then increases and eventually stabilizes between 400 and 500 feet btoc. Based on the gradual changes in temperature and fluid resistivity, no specific correlation between changes in these parameters and identified fracture zones is noted in the data.

Television Log – The clarity of the water in ITW was much higher than was observed in NBW, and therefore, the TV log was performed for the entire depth of the boring. In general, the lithology observed during the TV log of ITW was similar to that observed in the new bedrock boring (primarily gneiss and granite/pegmatite), however, the lithology was much more variable with depth in ITW. Frequent changes from gneiss to pegmatite and granite are noted in the TV log, indicating a higher degree of intrusion than was observed in the new bedrock boring. A general summary of observations made during the TV log is presented in Table 4.

Data Evaluation and Correlation Discontinuities identified in well ITW were similar to those in the new bedrock well, but had a higher degree of variability. Sets of high angle fractures dipping N10-50E and S15-45W were also identified in ITW. However, a second set of foliation and fractures is present with dip angles of 60 to 70 degrees and azimuths of 250-330 (southwest) degrees.

ITW also appears to contain a greater number of factures with low to moderate dip angles. A review of Table B-1 in the Hager report indicates that approximately 50% of the features identified in the ATV log are classified as having a low to moderate aperture potential, while only 16% of these features were classified by Hager as having a high aperture potential. The remaining features are classified as either quartz veining or foliation. Approximately 71% of the features classified by Hager as having a high aperture potential occur within the first 200 feet of the borehole, with 17 of the 42 features within the first 70 feet into the bedrock

6.0 Bedrock Well Installation

Based on the results of the geophysical investigation and discussions between Rizzo Associates, EPA and DEP, a final design for the nested well couplet in the new bedrock boring was completed. This design included the screening of a shallow bedrock monitoring well, designated NBW-U, from 56 to 66 feet btoc and a deep bedrock monitoring well, designated NBW-L, from 115 to 120 feet btoc.

Well installation activities were performed by Maine Test Boring on November 20-21, 2003 under the supervision of Rizzo Associates personnel. Bentonite chips were used to backfill the boring to a depth of 122 feet btoc. Two feet of filter sand was then added to the boring prior to setting the well screen for NBW-L from 120 to 115 feet btoc. The annular space around the well screen was backfilled with filter sand to a depth of 112 feet (3 feet above the top of the casing). Additional bentonite chips were added above the sandpack to a depth of 72 feet btoc. The bentonite was then allowed to hydrate overnight prior to screening NBW-U from 66 to 56 feet btoc. As with the lower well, the sandpack was extended to a point approximately two feet above the top of the well screen. The remaining annular space was backfilled to the surface using additional bentonite chips and the well cluster was completed with a locking standpipe set in concrete.

Rizzo Associates personnel returned to the Site in November 2003 to develop the newly installed wells and to collect preliminary groundwater samples for analysis. Well development was accomplished using a multi-stage submersible pump. The pump was surged in the well casing while pumping to draw the fine grained material out of the well and to consolidate the sandpack. Due to the limited recharge observed in both the upper and lower wells, pumping was performed intermittently rather than continuously. Initially, the water evacuated from the wells was gray and very silty. After several hours of intermittent pumping, the heavy sediment load in the purge water was reduced, but the water did not run clear. Laboratory analysis of groundwater samples collected from the wells identified 2 ug/L of 1,1 dichloroethane in the NBW-U sample and 100 ug/L of dimethylformamide (DMF) in the NBW-L sample.

A second round of well development was performed by Rizzo Associates personnel April 6-7 2004. A 2-inch diameter submersible pump and portable generator were utilized to purge NBW-U and NBW-L. As was observed during the initial round of development in November 2003, both NBW-U and NBW-L were immediately drawn dry by the pump and a constant pumping rate that could continuously overcome the rise in head pressure needed to lift the water to the ground surface but still pump slowly enough to not dewater the well, could not be achieved. Water pumped from the well contained large amounts of sediment and residual bentonite from the well seals. Clean water from well ITW was ultimately used to develop the two new bedrock wells. Water was added from ITW and the pump was surged to suspend and evacuate the sediment from the bottoms of the well casings. At the end of development activities, the recovery rates of NBW-U and NBW-L were monitored by gauging the depth to water at regular intervals. Table 5 below summarizes water level readings collected during the well development activities. Residual drawdown for each set of measurements is also presented in Table 5. As indicated by the data in the table, recharge in both wells was very slow. This data demonstrates the extremely poor recharge for wells screened in the bedrock on this portion of the Site.

Groundwater elevations based on data collected at the Site as part of the Q35 monitoring event indicate that NBW-L is located downgradient from B-8A-D. Based on water levels collected at the Site on April 13, 2004, the calculated groundwater elevation for B-8A-D was 350.95 feet above mean sea level (MSL) while the groundwater elevation for NBW-L was 348.70 feet above MSL.

Table 5 Well Development Data

Event	NBW-U	RDD (feet)	NBW-L	RDD (feet)
Static – 4/6/04	12.92 (6:00 pm)	0	21.87 (6:00 pm)	0
Post Development 4/7/04	53.18 (6:20 pm)	40.26	92.65 (7:00 pm)	70.78
Static – 4/7/04	38.55 (8:35 am)	25.63	73.85 (8:35am)	51.98
Post Development – 4/7/04	64.32 (1:00 pm)	51.40	119.08 (1:18 pm)	97.21
Final Recovery Reading – 4/7/04	58.96 (4:00 pm)	46.04	113.48 (4:00 pm)	91.61

All measurements in feet below the top of casing RDD - Residual Drawdown

7.0 Conclusions

The Trust and Rizzo Associates implemented a bedrock evaluation at the Site to assess the potential for migration of VOC-impacted groundwater through the deep bedrock at the Site. This investigation included the installation and geophysical evaluation of a deep bedrock boring on the downgradient portion of the Site. Based on the results of the investigation, a nested couplet of shallow and deep bedrock monitoring wells were completed in the boring.

In general, the results of the investigation were as follows:

- Based on the geophysical data, the majority of the fractures with "high aperture potential" dip in a southwestern direction, such that groundwater flowing in a down-dip direction in these fractures has the potential to flow from B-8A-D towards NBW-U and NBW-L, making it an acceptable downgradient bedrock monitoring point for contamination observed on the central portion of the Site. The results of a recent groundwater elevation survey support this conclusion.

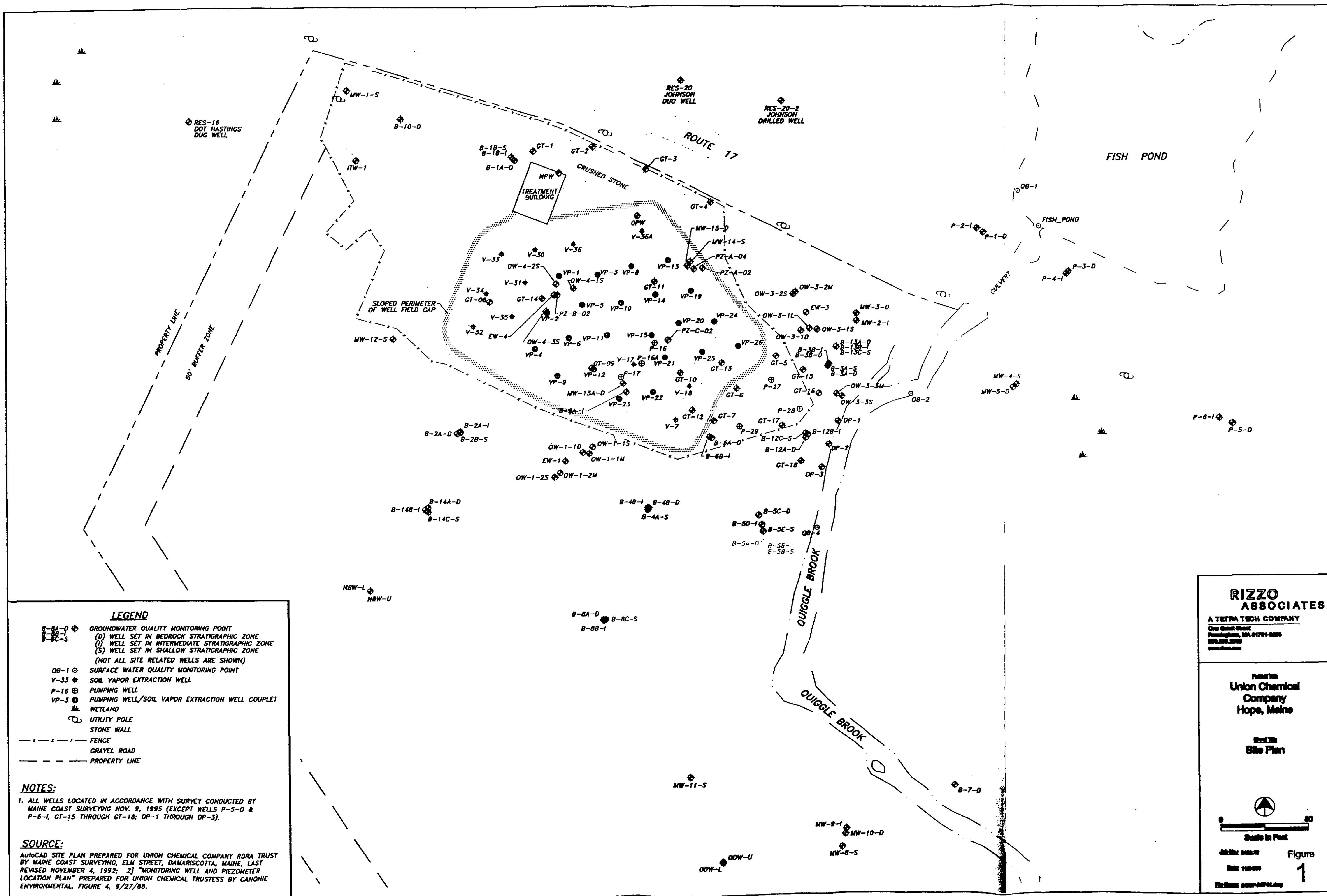
- Observations made during the installation, development and sampling of the new bedrock well cluster suggest that the bedrock has a very low transmissivity with few if any fracture zones capable of transmitting large volumes of groundwater. Due to the low number and small diameter of observed available fractures in the deep bedrock, groundwater flow and with it the potential migration of contaminants will likely be restricted or very slow at the Site.

Table 3
UCC Maine
ATV Log Comments - ITW

Depth (feet)	Comments
22.5	Bottom of drive casing
24-25	Large, moderately dipping fracture
27-30	Long vertical joint
42.5	Flat, low angle fracture
47	Low angle fracturing
50	Low angle fracturing
58-60	Steeply dipping fracture set
66.5-70	Long vertical fractures
72-73	Moderately dipping open fracture set
98	Sub horizontal fracture
102-103	Set of steeply dipping fractures
120-130	Evidence of sheeting/spauling
132	Subhorizontal fracture
144	Additional sheeting of borehole wall
178-181	Large amplitude, steeply dipping fracture
205-215	Steeply dipping fracture set
217-225	Several evenly spaced subhorizontal fractures
240	Set of steeply dipping fractures
306	Set of steeply dipping fractures
330	A few high angle fractures
399	Set of steeply dipping fractures
445	Steeply dipping fracture set
454-455	Steeply dipping fracture set
460-464	Several high angle fractures with opposite dips
468-470	Highly foliated
473-476	Several high angle fractures with opposite dips
478-480	Set of closely spaced fractures
482	Small/medium fracture set
485	Medium aperture fracture

Table 4
UCC Maine
Television Log Comments - ITW

Depth (feet)	Estimated Lithology	Comments
22-30	Granite/pegmatite	Some subhorizontal fractures, fairly coarse grained
35	*Granite/pegmatite*	*Numerous subhorizontal fractures and joints*
39	Granite/pegmatite	Trending finer grained, less foliation evident
45	Granite/pegmatite	SAA
50	Granite/pegmatite	Tight jointing
55	*Granite/pegmatite*	*Some joints and vertical fractures*
60	Granite/pegmatite	Foliation evident, some vertical fractures
65	Granite/pegmatite	Vertical jointing continues
70	Granite/pegmatite	SAA
75	Gneiss	Much darker, finer grained. Stronger foliation
80	Gneiss	Strong foliation, smooth borehole
85	Gneiss	Some remineralized vertical joints
90	Gneiss	Smooth, fine grained
95	Gneiss	Tightly foliated, fine grained gneiss
100	Pegmatite	Coarse grained
105	Pegmatite	High angle fractures/foliation
110	Pegmatite	Evidence of quartz vein filling
112	Gneiss	Evidence of partial melting
115	Pegmatite	Coarse grained
120	Pegmatite	Coarse grained
125	Pegmatite	High angle fractures, massive no foliation
130	Pegmatite	Massive, no foliation
135	Pegmatite	Trending finer grained
140 - 160	Pegmatite	Medium to coarse grained
175-215	Pegmatite	Coarse grained, high angle jointing
220	Gneiss	Foliated, some highly deformed quartz veining
230	Pegmatite	
233	Gneiss	
237	Pegmatite	High angle contact with silicious zone
240	Pegmatite	Closely spaced, mineralized fractures
250-255	Pegmatite	Medium to coarse grained, some vertical joints
258	Pegmatite	Possible large, open fracture
260-270	Pegmatite	Light colored, fine to medium grained, smooth
271	Gneiss	Contact with darker, mafic foliated rock
278-290	Gneiss	High angled qtz veining, strong foliation
295	Gneiss	Vertical filled offset fracture
325	Gneiss	Weaker foliation
330-335	Pegmatite	Medium to coarse grained
340	Granite	Contact with salt and pepper rock (granite)
345-360	Granite	Some moderate angle fractures and mafic stringers
360	Pegmatite	Less fracturing, becoming coarser grained
380	Gneiss	Contact with darker, mafic foliated rock
385 -390	Gneiss	Abundant quartz filled veins
395-405	Granite	Granitic texture, massive quartz zones, little foliation
408-415	*Pegmatite*	*High angle fractures*
420-430	Gneiss	Back into mafic rock, foliated, some qtz veining.
430	Gneiss	Filled brecciated zone, some clastic deformation
432	Pegmatite	Light colored, fine to coarse grained, some fracturing
445	Pegmatite	Hairline fractures
447-455	Gneiss	Dark, mafic rock, vertical foliation evident
465-485	Mixed	Mafic/mixed zone, highly deformed, some vertical fractures
490-500	Pegmatite	Fine to medium grained
501	Pegmatite	Bottom of Boring


ROUTE 17
FISH POND
CRUSHED STONE
TREATMENT BUILDING
NPW
SLOPED PERIMETER OF WELL FIELD CAP
PROPERTY LINE
50' BUFFER ZONE
QUIGGLE BROOK
QUIGGLE BROOK
CULVERT
FISH_POND
RES-16 DOT HASTINGS DUG WELL
RES-20 JOHNSON DUG WELL
RES-20-2 JOHNSON DRILLED WELL
MW-1-S
B-10-D
ITW-1
MW-12-S
B-1B-S
B-1B-I
B-1A-D
GT-1
GT-2
GT-3
GT-4
OPW
V-36A
MW-15-D
MW-14-S
PZ-A-04
PZ-A-02
V-33
V-30
V-36
OW-4-2S
VP-1
VP-3
VP-8
VP-13
OW-4-1S
V-31
GT-11
VP-14
VP-19
V-34
GT-08
GT-14
VP-5
VP-10
PZ-B-02
VP-2
V-35
V-32
EW-4
OW-4-3S
VP-6
VP-11
VP-15
VP-20
PZ-C-02
VP-24
VP-26
VP-4
P-16
VP-25
GT-09
V-17
P-16A
VP-21
GT-13
VP-12
P-17
GT-10
VP-9
MW-13A-D
V-18
VP-23
VP-22
GT-6
B-9A-I
GT-12
GT-7
V-7
OW-3-2S
OW-3-2M
OW-3-1L
EW-3
MW-3-D
MW-2-I
OW-3-1S
OW-3-1D
GT-5
B-13A-D
B-13B-I
B-13C-S
B-3B-I
B-3C-D
B-3A-S
B-3A-D
GT-15
P-27
GT-16
OW-3-3M
OW-3-3S
QB-2
P-28
DP-1
GT-17
P-29
B-12C-S
B-12B-I
B-12A-D
DP-2
B-6A-D
B-6B-I
GT-18
DP-3
B-2A-I
B-2A-D
B-2B-S
OW-1-1D
OW-1-1S
OW-1-1M
EW-1
OW-1-2S
OW-1-2M
QB-1
P-2-I
P-1-D
P-3-D
P-4-I
MW-4-S
MW-5-D
P-6-I
P-5-D
B-14A-D
B-14B-I
B-14C-S
B-4B-I
B-4B-D
B-4A-S
B-5C-D
B-5D-I
B-5E-S
QB-4
NBW-L
NBW-U
B-8A-D
B-8C-S
B-8B-I
MW-11-S
B-7-D
MW-9-I
MW-10-D
MW-8-S
ODW-U
ODW-L
LEGEND
B-8A-D
B-8B-I
B-8C-S
GROUNDWATER QUALITY MONITORING POINT
(D) WELL SET IN BEDROCK STRATIGRAPHIC ZONE
(I) WELL SET IN INTERMEDIATE STRATIGRAPHIC ZONE
(S) WELL SET IN SHALLOW STRATIGRAPHIC ZONE
(NOT ALL SITE RELATED WELLS ARE SHOWN)
QB-1 SURFACE WATER QUALITY MONITORING POINT
V-33 SOIL VAPOR EXTRACTION WELL
P-16 PUMPING WELL
VP-3 PUMPING WELL/SOIL VAPOR EXTRACTION WELL COUPLET
WETLAND
UTILITY POLE
STONE WALL
FENCE
GRAVEL ROAD
PROPERTY LINE
NOTES:
1. ALL WELLS LOCATED IN ACCORDANCE WITH SURVEY CONDUCTED BY MAINE COAST SURVEYING NOV. 9, 1995 (EXCEPT WELLS P-5-D & P-6-I, GT-15 THROUGH GT-18; DP-1 THROUGH DP-3).
SOURCE:
AutoCAD SITE PLAN PREPARED FOR UNION CHEMICAL COMPANY RDRA TRUST BY MAINE COAST SURVEYING, ELM STREET, DAMARISCOTTA, MAINE, LAST REVISED NOVEMBER 4, 1992; 2] "MONITORING WELL AND PIEZOMETER LOCATION PLAN" PREPARED FOR UNION CHEMICAL TRUSTESS BY CANONIE ENVIRONMENTAL, FIGURE 4, 9/27/88.
RIZZO ASSOCIATES
A TETRA TECH COMPANY
Union Chemical Company Hope, Maine
Site Plan
0
80
Scale in Feet
Figure 1
J:\Project\2420\Plot\Q34\SitePlans\2420P-ESP01.dwg 02/06/2004 12:31:02 PM EST

APPENDIX A

Appendix A

Limitations

Appendix A: Limitations

1. The observations described in this report were made under the conditions stated therein. The conclusions presented in the report were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by Client. The work described in this report was carried out in accordance with the Terms and Conditions in our contract.

2. In preparing this report, Rizzo Associates has relied on certain information provided by state and local officials and other parties referenced therein, and on information contained in the files of state and/or local agencies available to Rizzo Associates at the time of the site assessment. Although there may have been some degree of overlap in the information provided by these various sources, Rizzo Associates did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this site assessment.

3. Observations were made of the Site and of structures on the Site as indicated within the report. Where access to portions of the Site or to structures on the Site was unavailable or limited, Rizzo Associates renders no opinion as to the presence of hazardous materials or oil, or to the presence of indirect evidence relating to hazardous material or oil, in that portion of the Site or structure. In addition, Rizzo Associates renders no opinion as to the presence of hazardous material or oil, or the presence of indirect evidence relating to hazardous material or oil, where direct observation of the interior walls, floor, or ceiling of a structure on a Site was obstructed by objects or coverings on or over these surfaces.

4. Rizzo Associates did not perform testing or analyses to determine the presence or concentration of asbestos at the Site or in the environment at the Site.

5. It is ENGINEER's understanding that the purpose of this report is to assess the physical characteristics of the subject Site with respect to the presence on the Site of hazardous material or oil. This stated purpose has been a significant factor in determining the scope and level of services provided for in the Agreement. Should the purpose for which the Report is to be used or the proposed use of the site(s) change, this Report is no longer valid and use of this Report by CLIENT or others without ENGINEER's review and

written authorization shall be at the user's sole risk. Should ENGINEER be required to review the Report after its date of submission, ENGINEER shall be entitled to additional compensation at then existing rates or such other terms as agreed between ENGINEER and the CLIENT.

6. The conclusions and recommendations contained in this report are based in part, where noted, upon the data obtained from a limited number of soil samples obtained from widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until further exploration. If variations or other latent conditions then appear evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

7. Any water level readings made in test pits, borings, and/or observation wells were made at the times and under the conditions stated on the report. However, it must be noted that fluctuations in the level of groundwater may occur due to variations in rainfall and other factors different from those prevailing at the time measurements were made.

8. Except as noted within the text of the report, no quantitative laboratory testing was performed as part of the site assessment. Where such analyses have been conducted by an outside laboratory, Rizzo Associates has relied upon the data provided and has not conducted an independent evaluation of the reliability of these data.

9. The conclusions and recommendations contained in this report are based in part, where noted, upon various types of chemical data and are contingent upon their validity. These data have been reviewed and interpretations made in the report. As indicated within the report, some of these data may be preliminary screening level data and should be confirmed with quantitative analyses if more specific information is necessary. Moreover, it should be noted that variations in the types and concentrations of contaminants and variations in their flow paths may occur due to seasonal water table fluctuations, past disposal practices, the passage of time, and other factors. Should additional chemical data become available in the future, these data should be reviewed, and the conclusions and recommendations presented herein modified accordingly.

10. Chemical analyses have been performed for specific constituents during the course of this site assessment, as described in the text. However, it should be noted that additional chemical constituents not searched for during the current study may be present in soil and/or groundwater at the Site.

11. This Report was prepared for the exclusive use of the CLIENT. No other party is entitled to rely on the conclusions, observations, specifications, or data contained therein without the express written consent of ENGINEER.

12. The observations and conclusions described in this Report are based solely on the Scope of Services provided pursuant to the Agreement. ENGINEER has not performed any additional observations, investigations, studies, or testing not specifically stated therein. ENGINEER shall not be liable for the existence of any condition, the discovery of which required the performance of services not authorized under the Agreement.

13. The passage of time may result in significant changes in technology, economic conditions, or site variations that would render the Report inaccurate. Accordingly, neither the CLIENT, nor any other party, shall rely on the information or conclusions contained in this Report after six months from its date of submission without the express written consent of ENGINEER. Reliance on the Report after such period of time shall be at the user's sole risk. Should ENGINEER be required to review the Report after six months from its date of submission, ENGINEER shall be entitled to additional compensation at then existing rates or such other terms as may be agreed upon between ENGINEER and the CLIENT.

14. ENGINEER has endeavored to perform its services based upon engineering practices accepted at the time they were performed. ENGINEER makes no other representations, express or implied, regarding the information, data, analysis, calculations, and conclusions contained herein.

15. The services provided by ENGINEER do not include legal advice. Legal counsel should be consulted regarding interpretation of applicable and relevant federal, state, and local statutes and regulations and other legal matters.

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APPENDIX B

Appendix B

Boring Logs / Monitoring Well Completion Diagrams

Maine Dept. of Environmental Protection
Bureau of Remediation and Waste Management
Division of Technical Services

LOG OF BEDROCK BORING

Project Name: Union Chemical Company Site	Location: South Hope, Maine
Drilling Method: Air Rotary/Reichdrill T-690W	Sheet 1 of 2
Bit Diameter: 5 7/8"	Boring No. Not Available
Casing Diameter: 6"	Logged By: H. Andolsek, C.G. #325
Total Depth: 302'	Drilling Contractor: Bowie Brothers
Sampling Method: Cuttings @ 1-foot intervals	Driller: John Adams
Water Level: Not Recorded	Latitude: Not available
Start Time/Date: 09:15 10/28/03	Longitude: Not available
End Time/Date: 16:00 10/28/03	Surface Elevation: Not available
Discharge Rate: 2 gpm	Casing Elevation: Not available
Casing Depth: 52' -grouted w/Portland Type I/II	Depth to Bedrock: 47'
Drilling Water Source: Bowie Brother's Well	

Time	Depth (ft. bgs)	DESCRIPTION	COMMENTS
9:15	0.0	Overburden consists of till and glacial-marine clay. Using mud rotary to drill pilot hole for casing.	start drilling
10:35	47.0		bedrock surface
10:50	52.0	Completed drilling 8" rock socket for surface casing.	begin mixing grout
11:03			install casing
12:10			grouting casing in place
12:45	52.0		start rock drilling
	52.0		**Driller reports fracture (DRF)**
12:50	61.5	Qtz, biotite, feldspar, amphiboles (Granite)	
~12:59	69.0		**DRF**
~13:00	75.0	Light gray/white Granite	possible pegmatite
13:03	81.5	Weathered rock, brown oxided chips, larger chips than usual	**possible fracture**
13:06			start 5th rod
	84.0	white qtz, mica, Granite pegmatite	
	85.0	Gneiss, trace, oxidized chips	
	86-95	Gneiss, trace qtz.	
	96.0	Granite pegmatite	
	97-100	Gneiss	
	100-101	Granite pegmatite	
13:22			start 6th rod
	104.0	Light gray Gneiss	
	105-114	Dark gray/purple Gneiss	
	114-116	becoming darker gray/black (Gneiss)	
	116-121	Light gray Gneiss	**DRF @ 117'** - no evidence of fracture, could be due to low O_2 reducing the iron
13:40			start 7th rod
	124-139	dark gray Gneiss; tr qtz.	**DRF @ 136', 140', 142'**
	139-141	Light gray Gneiss; tr pyrite and clay globs	Clay possibly fault gouge Borehole is making water.
13:54			start 8th rod
	145-146	dark gray Gneiss	
	146-147	qtz (Granite pegmatite)	
	147-148	light gray Gneiss, some qtz	
	148-162	dark gray Gneiss	

Project Name: Union Chemical Company Site	Boring No. Not Available
Start Time/Date: 09:15 10/28/03	Logged By: H. Andolsek, C.G. #325
End Time/Date: 16:00 10/28/03	Sheet_2__of _2___

Time	Depth (ft. bgs)	DESCRIPTION	COMMENTS
14:07			start 9th rod
	164-172	dark gray Gneiss	
	172-182	white qtz., tr biotite, muscovite and amphibole (Granite pegmatite)	
14:21			start 10th rod
	184-202	white qtz., tr biotite, muscovite and amphibole (Granite pegmatite)	
14:35			start 11th rod
	204-220	gray Gneiss	
	220-221	white qtz., mica (Granite pegmatite)	
	221-222	gray Gneiss	no evidence of fractures
14:42			start 12 rod
	224-242	dark gray/purple Gneiss, tr mica. Qtz content increases at 237-238'.	
15:09			start 13th rod
	244-252	gray/purple Gneiss	
	252-262	white qtz, tr muscovite (Granite pegmatite)	
15:25			start 14th rod
	265-277	white qtz, trace mica (Granite pegmatite)	
	278-280	gray/purple Gneiss, little qtz.	
	280-282	gray/purple Gneiss, tr qtz.	
15:39			start 15th rod
	285-299	gray/purple Gneiss; highly graphitic from 285' to 295'	
	299-301	gray/purple Gneiss; some qtz.	
	301-302	light brown/purple Gneiss; some qtz, finer chips.	B.O.B.
15:57			check discharge: 2 gpm sweet smell as water is first purged from well
			Bill Phelps (Rizzo) collects sample of discharge water for head space test using MiniRae: ~175 ppm
16:10			stop developing

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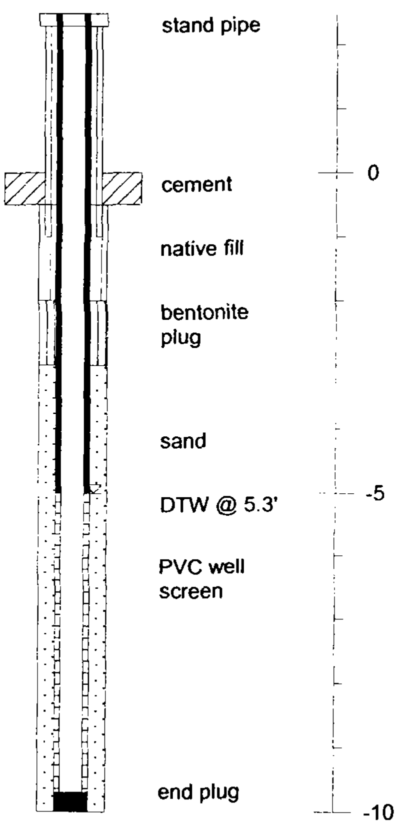
A TETRA TECH COMPANY
One Grant Street, Framingham, MA, 01701

Boring Log and Well Diagram

Boring Number: B-5C-S
Total Depth: 10 ft

Project Name:	Union Chemical	Drilling Company:	Maine Test Boring
Site Location:	214 Main Street South Hope, Maine	Driller:	Tom Schaefer
		Drill Equipment:	Bombadier
Project Number:	2420	Drill Method:	Solid Stem Auger/Drive & Wash
Inspector:	Bill Phelps	Sample Type:	NA
Dates Drilled:	10/27/03	Hammer Size:	140 lbs. Boring Diameter:
Notes:	Heavy rain, 60 F. Replacement well for B-5B-S		

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
							Boring not logged. See log for B-5B-S for soil description.	



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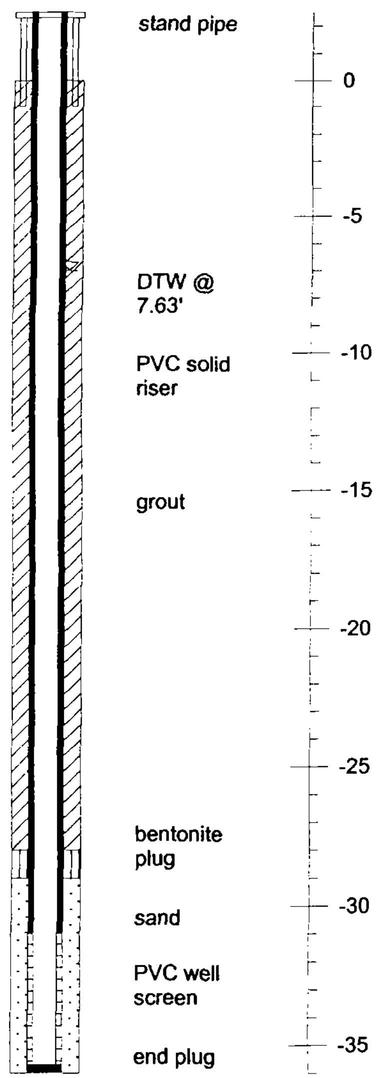
Boring Log and Well Diagram

Boring Number: B-5D-I

Total Depth: 36 ft

Project Name:		Drilling Company:	Maine Test Boring
Site Location:	2420 South Hope, Maine	Driller:	Tom Schaefer
		Drill Equipment:	Bombadier
Project Number:	Union Chemical	Drill Method:	Hollow Stem Auger/Drive & Wash
Inspector:	Bill Phelps	Sample Type:	NA
Dates Drilled:	10/29/03 - 10/30/03	Hammer Size:	140 lbs.
Notes:	Clear, 45 F, Replacement well fro B-5B-I		

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks



Boring not logged. See log for B-5B-I for soil description.

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One Grant Street, Framingham, MA, 01701

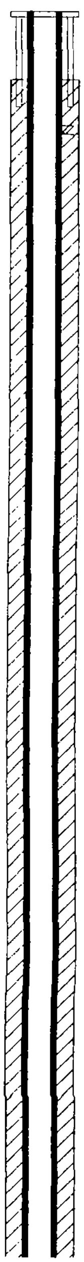
Boring Log and Well Diagram

Boring Number: B-5E-D

Total Depth: 73 ft

Project Name:	Union Chemical	Drilling Company:	Maine Test Boring
Site Location:	214 Main Street South Hope, Maine	Driller:	Tom Schaefer
		Drill Equipment:	Bombadier
Project Number:	2420	Drill Method:	Drive & Wash
Inspector:	Bill Phelps	Sample Type:	NA
Dates Drilled:	10/28/03 - 10/29/03	Hammer Size:	140 lbs.
Notes:	Heavy rain and wind, 50 F. Replacement well for B-5A-D		

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
							Boring not logged. See log for B-5A-D for soil description.	



stand pipe

DTW @ 2.45'

PVC solid riser

grout

Depth (ft.): 0, -5, -10, -15, -20, -25, -30, -35, -40

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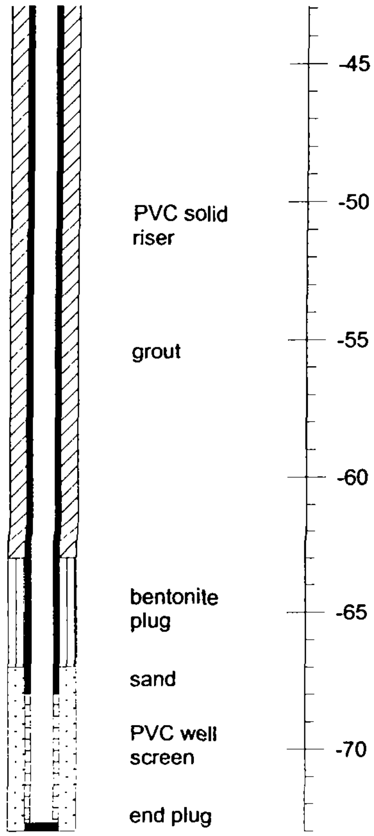
Boring Number: B-5E-D

Project Name: Union Chemical
Project Number: 2420

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
PVC solid riser; grout	-45 to -63							
bentonite plug	-63						PEGMATITE: Coarse grained PEGMATITE	Bedrock encountered at 63 ft. Switch to HQ Core Barrel.
sand	-66						PEGMATITE: Fine grained PEGMATITE	
PVC well screen; end plug	-69						SAA: SAA	See separate log for full rock descriptions.



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One Grant Street, Framingham, MA, 01701

Boring Log and Well Diagram

Boring Number: NWB-L

Total Depth: 122 ft

Project Name:	Union Chemical	Drilling Company:	Bowie Brothers Well Drilling / Maine Test Boring
Site Location:	214 Main Street South Hope, Maine	Driller:	John Adams / Tom Scheafer
		Drill Equipment:	Reichdrill T-690W
Project Number:	2420	Drill Method:	Air Rotary
Inspector:	Bill Phelps / Chris Nitchie	Sample Type:	NA
Dates Drilled:	10/28/03 and 11/20/03	Hammer Size:	
Notes:	Overcast w/scatterred rain showers, 56 F		

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
standpipe								
cement	0						TILL: Undifferentiated Overburden	Boring not logged.
	-5							
bentonite	-10							
	-15							
	-20							DTW - 21.87 feet btoc
	-25							
	-30							
2" dia Sch 40 solid PVC riser	-35							
	-40							
	-45							
	-50						BEDROCK: See attached DEP log for bedrock lithology description.	Bedrock @ 53 ft
	-55							
sand (sand pack for NBW-U)	-60							
	-65							
	-70							
	-75							

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
	-75							
	-80							
bentonite	-85							
	-90							
	-95							
	-100							
	-105							
	-110							
sand pack	-115							Boring originally drilled to 302 feet bgs, backfilled with bentonite chips to 120 feet bgs.
2" dia PVC, Sch 40 10 slot well screen	-120							
	-125							
	-130							
	-135							
	-140							
	-145							
	-150							
	-155							
bentonite	-160							
	-165							
	-170							
	-175							
	-180							

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Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
	-185							
	-190							
	-195							
	-200							
	-205							
	-210							
	-215							
	-220							
	-225							
bentonite	-230							
	-235							
	-240							
	-245							
	-250							
	-255							
	-260							
	-265							
	-270							
	-275							
	-280							
	-285							

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A TETRA TECH COMPANY

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
bentonite	-290							
	-295							
	-300							

RIZZO ASSOCIATES

A TETRA TECH COMPANY
One Grant Street, Framingham, MA, 01701

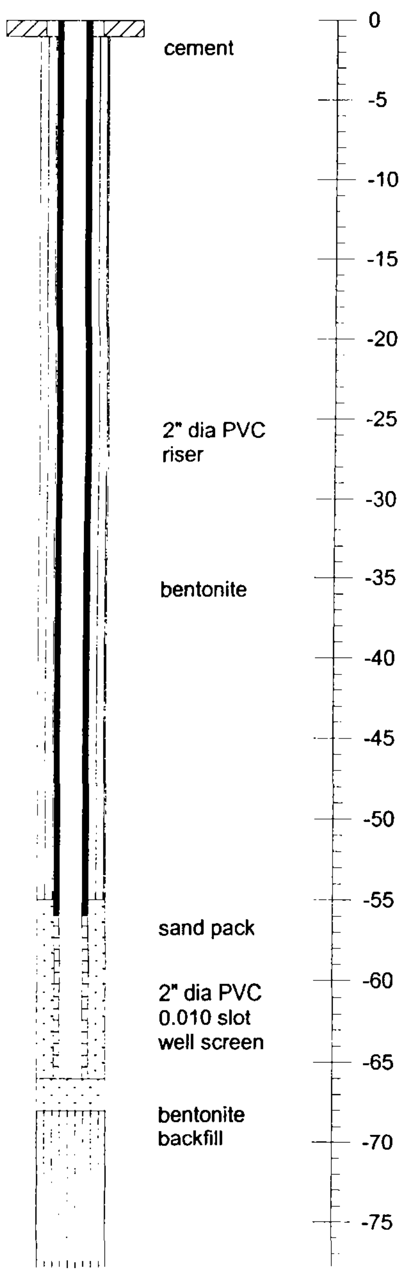
Boring Log and Well Diagram

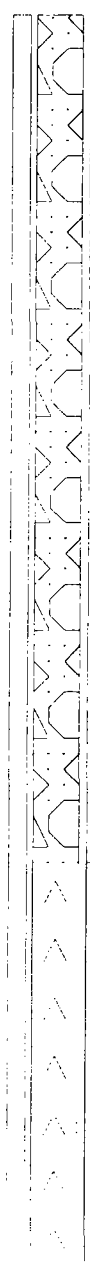
Boring Number: NBW-U

Total Depth: 66 ft

Project Name:	Union Chemical	Drilling Company:	Bowie Brothers Well Drilling / Maine Test Boring
Site Location:	214 Main Street South Hope, Maine	Driller:	John Adams / Tom Scheafer
		Drill Equipment:	Reichdrill T-690W
Project Number:	2420	Drill Method:	Air rotary
Inspector:	Chris Nitchie	Sample Type:	NA
Dates Drilled:	10/28/03 and 11/20/03	Hammer Size:	
Notes:	Overcast w/scatterred rain showers, 56 F		

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks





Depth	Material Description	Remarks
0 – 53	TILL: Undifferentiated Overburden	
53 –	BEDROCK: Bedrock - See DEP log for bedrock lithology discussion.	Bedrock @ 53 ft Boring originally drilled to 302 feet bgs. Backfilled with bentonite chips to 68 feet bgs

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A TETRA TECH COMPANY

Boring Number: NBW-U

Project Name: Union Chemical
Project Number: 2420

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
	-80							
	-85							
	-90							
	-95							
	-100							
	-105							
	-110							
	-115							
	-120							
	-125							
	-130							
	-135							
	-140							
	-145							
bentonite	-150							
	-155							
	-160							
	-165							
	-170							
	-175							
	-180							

RIZZO ASSOCIATES
A TETRA TECH COMPANY

Boring Number: NBW-U

Project Name: Union Chemical
Project Number: 2420

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
	-185							
	-190							
	-195							
	-200							
	-205							
	-210							
	-215							
	-220							
	-225							
	-230							
	-235							
	-240							
bentonite	-245							
	-250							
	-255							
	-260							
	-265							
	-270							
	-275							
	-280							
	-285							

Well Construction	Depth (ft.)	Blow Counts per 6 in.	Recovery/Advance	PID (ppm)	Sampled Interval	Graphic Log	Material Description	Remarks
	-290							
bentonite	-295							
	-300							

APPENDIX C

Appendix C

Hager GeoSciences Report

BOREHOLE GEOPHYSICAL LOGGING
FORMER UNION CHEMICAL COMPANY SITE
SOUTH HOPE, MAINE

Prepared for:

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File 200353
January 2004

1.0 INTRODUCTION

Hager GeoScience, Inc. (HGI) was contracted by Rizzo Assoc., Inc. to perform geophysical borehole logging at the former Union Chemical Company (UCC) Site in South Hope, Maine. The site was previously used by UCC as part of their solvent recovery operations, which resulted in releases of VOCs.

The goal of the logging was to acquire oriented fracture/discontinuity, flow rate, and other bedrock data from two boreholes, one previously existing (IT-W) and the second recently installed (RIZ-1B). Fieldwork was performed from November 12 to 14, 2003 and observed by Rizzo personnel.

At Rizzo's request, preliminary logs were provided as hard copies and images, along with a log reader, to both the Maine DEP and Rizzo on November 17th and 18th.

2.0 DATA ACQUISITION

The HGI logging system consisted of a Mount Sopris Instruments 5MCA-1000 MGXII logger and MSI 4MXA-1000 winch; MSI 2PEA/F_0-2500Ohm-m,T, FR combination polyelectric probe including fluid temperature/resistivity and natural gamma probes; MSI 2CAA-1000 three-arm caliper probe; Advanced Logic Technologies FAC40 acoustic televiewer (ATV); MSI HFP-2293 Heat Pulse Flow Meter (HPFM); and GeoVision Jr. black and white borehole video system.

Six consecutive logging runs were made in IT-W and in RIZ-1B as follows: caliper, polyelectric, ATV, HPFM-ambient, HPFM-stressed, and borehole camera. A computer housed in the HGI logging truck controlled the system. An HGI geologist monitored the logs in real time during data acquisition and recorded hardware and software settings as well as data anomalies in a logbook and on forms developed for the project. Raw data from the logging runs were stored digitally on the computer for later analysis and plotting.

Logging Procedure

Data for the polyelectric and caliper logs were collected at 0.05-foot intervals at logging rates of 8 to 12 feet per minute, respectively. The caliper probe was calibrated according to manufacturer's specifications on-site before each run. ATV data were collected at 0.01-foot intervals at a logging rate of approximately 2 feet per minute. A scan time of 1000 and 1250 μsec were used, with a sample rate of 288 measurements per revolution. HPFM measurements were taken under both ambient and stressed conditions at depth intervals specified by a Rizzo representative based on the preliminary logging data.

The logging tools and cable were cleaned after each run with soap followed by a clean water rinse.

The logs and their purpose are described in more detail below:

Run #1:

Caliper Probe

Caliper logs record borehole diameter. Changes in borehole diameter are related to well construction, such as casing or drilling-bit size, and to fracturing or caving along the borehole wall. Because borehole diameter commonly affects log response, the caliper log is useful in the analysis of other geophysical logs. Caliper and acoustic televiewer data are combined to produce 3D "virtual cores."

Run #2:

Polyelectric Probe

Normal formation resistivity measures the electrical resistivity, in ohm-meters, of the rocks surrounding the borehole and interstitial water. Variably spaced potential electrodes on the logging probe provide resistivity measurements ranging from shallow to deep penetration into the borehole wall. Spacing of the potential electrodes is 8, 16, 32, and 64 inches.

Single point resistance measures the electrical resistance from points within the borehole to an electrical ground at the surface. In general, resistance increases with increasing grain size and decreases with increasing borehole diameter, fracture density, and concentration of dissolved solids in the water. When used in combination with other logs, single-point resistance logs are useful in determining lithology, water quality, and location of fracture zones.

Spontaneous potential measures the electrical potential developed between the borehole fluid and the surrounding materials. Spontaneous potential logs can be used to help determine lithology and water quality.

Gamma Probe:

Natural gamma is used to determine the presence and location of clay-filled fractures. These logs record the amount of gamma radiation emitted by the rocks surrounding the borehole. The most significant naturally occurring sources of gamma radiation are potassium-40 and daughter products of the uranium- and thorium-decay series. Shale and clay-filled fractures commonly emit relatively high gamma radiation because they include weathering products of potassium feldspar and mica and tend to concentrate uranium and thorium by ion absorption and exchange.

Fluid Temperature/Resistivity Probe:

Fluid Temperature logs record water temperature with depth in the borehole. These logs are useful for delineating water-bearing zones and identifying vertical flow in the borehole between zones of differing hydraulic head penetrated by wells. Borehole flow between zones is indicated by temperature gradients that are less than the regional geothermal gradient, which is about 1 degree Fahrenheit per 100 feet of depth.

Fluid resistivity logs measure the electric resistivity of water in the borehole. Changes in fluid resistivity reflect differences in the concentration of dissolved solids in water. Fluid resistivity logs are useful for delineating water-bearing zones in the borehole.

Run #3:

Acoustic Televiewer (ATV) Probe

Acoustic televiewer logs are images of reflected acoustic energy representing the acoustic impedance of the borehole wall. Differences in travel time and reflection amplitudes from background values are seen as anomalous features. A magnetometer and accelerometer are used to provide the corrected orientation and shape of the imaged features. As a result, it is possible to calculate the strike and dip of imaged planar features. ATV features or discontinuity images include open or filled fractures, foliation, and mineralized and weathered zones.

RUN #s 4 and 5 (RIZ-1B) /RUN #s 5 and 6 (IT-W):

HPFM Logs

Heat Pulse Flowmeter. Heat-pulse flowmeter (HPFM) logs use thermistors and temperature sensors in a tool constructed with known geometry. Diverters are used to isolate the interval to be measured. The HPFM measures the direction and rate of low vertical flow in the borehole. Both low- and high-flow HPFM probes are available to resolve flow rates from 0.02 to 1.0 gal/min. and greater than 1.0 gal/min., respectively. Accurate measurements require sufficient time between readings for the area around the tool to stabilize. At least three readings, each lasting up to 10 seconds, are required per interval to obtain a reasonable average measurement. The HPFM log runs are conducted under both ambient and stressed well conditions.

RUN # 6 (RIZ-1B) /RUN # 4 (IT-W):

Borehole Camera Video Log

The borehole video system consists of a black and white borehole camera head with lighted diodes mounted on a cable-controlled swivel and connected by a coaxial cable to a VCR recorder. Narration is provided using a microphone attached to the VCR recorder. The system is primarily used to observe wall conditions and geologic features in boreholes.

3.0 DATA REDUCTION

Preliminary results were provided as log printouts using WELLCAD for Windows© at a scale of 1 inch to 10 feet. Preliminary ATV logs were also provided electronically with a WELLCAD© reader at a scale of 1 foot to 10 feet. This scale allows the user to better observe the geometry of imaged structural features.

Borehole logging data were processed as graphical logs using WELLCAD for Windows© software system and Excel spreadsheets. Logs were compiled onto a one-sheet format to allow for more efficient graphical log analysis. Data ranges were set to optimize the detection of readings that depart from baseline and background values. Field logging depths were referenced to the ground surface.

Structure logs identifying notable and representative discontinuities from ATV data were constructed using WELLCAD. Borehole image and deviation logs were rotated from the magnetic north reference markers to account for a magnetic declination of 16 degrees east. Depths are relative to ground level, and all structural data are relative to true north. The structure (discontinuity) data (Appendix B, Tables B-1 and B-2) were used to calculate dip direction and dip angles, which were then used to construct stereonets (Appendix A, Stereonet Logs, CD in pocket). The stereonet format is a southern hemisphere equal-area Schmidt polar projection. The data (poles) have been classified and color-coded as to the relative openness of the imaged discontinuities. The ranking system is based on caliper, acoustic amplitude, and acoustic travel time logs. The ranking index is subjective and attempts to qualitatively identify the potential weakness of the individual discontinuities. Color-coded pole plots have also been provided separately for quartz veins and, in well IT-W, foliation.

ATV logs are presented as 2D images of the borehole. 3D virtual cores have been constructed using the caliper logs and reflection amplitude. These views are useful in defining the characteristics of the core and discontinuities. 3D views are available in the electronic file using the WELLCAD reader. Borehole deviation graphs constructed for each well are also viewable using the WELLCAD reader.

Two sets of logs, each containing three logs for each well, are provided on the CD in Appendix A. They include a combination log, 3D log with ATV, 3D core image, caliper, HPFM logs, and a stereonet log. The combination and 3D logs contain embedded deviation plots and a 3D virtual core that can be manipulated for various perspectives using the WELLCAD reader provided on the CD.

4.0 RESULTS

The data show that the bedrock in each borehole is similar in composition, with variable degrees of metamorphic textures, partly attributable to the variation in depth of the two wells. RIZ-1B appears to be primarily granite gneiss with larger intervals of quartz pegmatite and amphibolite. The predominant discontinuities are high-angle fractures dipping N15-50E and S10-60W; possibly conjugate fracture sets. Discontinuities with NW dip directions are also present. Few discontinuities were observed with SE dips.

IT-W is similar in composition to RIZ-1B; however, the texture is more variable. IT-W is structurally more complex than RIZ-1B and contains larger intervals of granite pegmatite and amphibolite, better-developed foliation/cleavage, and a higher concentration of discontinuities. A predominant set of discontinuities in IT-W are also high-angle fractures dipping N10-50E and S15-45W, also possible conjugate fracture sets. However, an equally dominant set of foliation and fractures is present with dip angles of 60-70 degrees and predominant dip azimuths of 250-330 degrees. IT-W also contains a higher number of fractures with low to moderate dip angles (30-50 degrees) and larger apparent aperture. Although the moderate dips are generally well distributed, a small NW-SW dip azimuth is favored.

It is beyond the scope of this report to provide detailed log analyses; however, the following general observations are useful to evaluating the data from these two wells.

There is very good correlation between the log data and borehole features. The combination logs are designed to include the log traces most helpful in observing these correlations. Lithology changes are readily observed as changes in amplitude in the ATV log and shifts in the natural gamma baseline (lower counts for siliceous zones) and resistivity curve (high resistivity values for siliceous zones). Open, weathered fractures are observed as lower-amplitude zones in the ATV log, high count "kicks" in the natural gamma, and low kicks in the resistivity logs. In addition to HPFM measurements, in-flow from fractures can be observed as shifts in the fluid resistivity and water temperature logs. High-count natural gammas "kicks" have been observed within siliceous intervals with no fractures, suggesting mineralization. An example of the above relationships can be observed in Appendix A in the IT-W combination log for the interval between 160 and 190 feet.

5.0 LIMITATIONS OF ATV DATA

The ATV must be properly centered in the borehole to provide clear images. Eccentricity of the ATV tool in the borehole will produce an asymmetrical pattern of the acoustic wave front emanating from the tool, thereby making it difficult to establish a uniform background amplitude and travel-time log of the reflected energy against which the anomalous reflections can be discerned. Borehole tilt and small borehole diameters both degrade data quality. Borehole deviation plots in Appendix A indicate that the borehole migration was 22 feet for RIZ-1B and 53 feet for IT-W.

ATV features or discontinuities may represent open or filled fractures, foliation, and mineralized or weathered zones. Interpreting the type of feature present from the ATV log requires using other logs or core data, if available. For open fractures imaged in the ATV log, the width of the feature does not represent the true aperture. A portion of the acoustic energy hitting the fracture surface is diffracted. The recorded arrivals of these diffractions will appear on the log above and below the normal position of the fracture edges as lower-amplitude arrivals with longer travel times. Subtle changes in amplitude within each discontinuity can be used to approximate the true aperture; however, the measurement is approximate and should be designated as "apparent aperture."

**APPENDIX A – CD CONTAINING BOREHOLE LOGS
(IN POCKET)**

US EPA New England
Office of Site Restoration and Remediation Records & Information Center
Superfund Document Management System
Target Sheet

SDMS Document ID #257490______________________________

Site Name: _UNION CHEMICAL ______________________

File Number: ____
____

Purpose of Target Sheet:

[ ] Oversized [ ] Color

[X] Non-Paper Media [ ] Other (Provide purpose below)

____
____

Document Type this Target Sheet Replaces:

[ ]	Map	[ ]	Photograph	[ ]	Graph/Chart
[ ]	Video	[X]	Compact Disk	[ ]	Other (Specify below)

TRANSDUCER DATA [referenced in APPENDIX C - Appendix A: CD Containing Borehole Logs] _

Description or Comments: ________________________________

[ ] Stored outside site file [ ] Available in PDF

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APPENDIX B – DISCONTINUITY TABLES

TABLE B-1: WELL IT-W
TABLE B-2: WELL RIZ-1B

Dip Codes

105= High = Red
106 = Moderate = Green
107 = Low = Blue
109 = Quartz = Yellow
110 = Foliation = Purple

TABLE B-1
Well No. IT-W Discontinuities

Depth	Dip Azimuth	Dip Angle	Dip Code
28.0	54.0	42.3	105
28.7	90.2	47.0	105
28.8	209.2	74.6	105
29.1	215.6	73.2	105
29.7	206.4	75.2	106
35.5	145.9	65.6	107
37.9	241.2	47.3	106
38.6	266.5	79.5	107
39.7	353.9	76.3	107
42.4	73.5	70.2	106
42.6	198.9	74.4	106
42.8	0.5	66.6	109
43.0	10.4	62.1	106
43.1	167.4	69.6	107
46.4	207.3	42.2	105
46.7	204.1	39.1	105
51.1	154.9	34.8	105
51.2	186.6	21.3	105
52.2	329.1	65.1	107
53.6	286.9	53.8	105
53.8	267.2	48.0	105
57.3	241.9	39.8	107
58.5	350.3	78.0	107
61.5	47.9	77.4	107
62.3	221.1	81.1	107
63.6	212.0	74.5	105
63.8	210.0	73.9	105
64.2	217.7	57.9	106
64.3	213.0	57.8	106
65.1	249.6	69.2	107
66.5	261.7	53.7	107
68.2	98.3	78.9	107
70.0	315.2	70.5	107
70.4	323.9	70.1	107
72.4	184.5	66.9	109
74.7	190.2	57.1	107
74.8	289.9	63.4	107
76.4	187.1	80.5	106
79.8	354.8	42.5	107
85.1	315.8	48.4	107
86.4	220.6	82.4	107
87.5	156.6	89.6	109
97.7	221.8	78.1	105
98.0	215.7	75.3	105
99.8	61.8	80.8	106
101.9	181.0	44.4	105
102.1	174.3	44.5	105
102.4	116.0	53.9	107
105.6	214.8	81.1	105
106.1	187.9	71.2	107
106.4	204.1	76.5	106
112.1	94.6	79.8	106
112.8	77.6	79.6	106

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TABLE B-1
Well No. IT-W Discontinuities

Depth	Dip Azimuth	Dip Angle	Dip Code
117.6	145.1	77.7	107
120.0	221.6	38.5	107
120.6	272.2	76.0	106
121.5	279.6	74.1	106
122.8	124.5	76.2	107
125.5	152.8	58.1	106
125.5	259.2	82.2	106
125.5	266.6	83.7	106
126.5	309.9	81.6	107
127.0	263.1	75.7	110
127.5	293.1	78.9	110
128.5	304.1	76.8	110
129.5	291.0	71.8	110
130.0	323.3	61.2	110
130.3	315.0	64.0	110
130.8	309.0	69.5	110
136.1	194.6	13.8	107
136.4	157.7	19.5	107
148.0	16.3	50.7	105
148.5	174.3	57.8	105
148.7	187.6	70.9	106
151.5	41.6	69.0	110
151.9	49.3	68.7	110
152.2	35.9	69.7	110
153.3	171.0	40.0	105
153.8	158.5	36.4	105
157.4	35.0	68.5	110
161.6	30.2	62.1	106
162.0	27.4	65.9	105
165.3	18.0	71.5	105
165.7	20.9	67.5	105
166.6	323.0	57.0	110
167.1	312.8	63.4	110
167.6	292.4	62.9	110
168.2	301.6	63.7	110
169.4	347.7	64.8	109
170.0	342.1	61.1	109
170.4	357.1	71.2	106
171.1	21.9	59.9	109
172.1	78.4	30.7	106
173.5	128.5	33.6	105
173.9	130.9	32.2	105
180.0	64.5	41.4	105
180.3	74.8	37.5	105
181.5	175.3	50.7	106
181.9	163.1	48.3	106
183.5	203.8	85.1	105
184.4	204.1	86.7	105
189.0	47.3	50.6	107
189.4	23.6	26.7	107
191.6	11.6	54.0	109
192.1	23.4	58.6	109
193.0	23.4	38.2	109

TABLE B-1
Well No. IT-W Discontinuities

Depth	Dip Azimuth	Dip Angle	Dip Code
197.0	15.1	67.1	109
197.2	7.6	64.5	109
208.7	209.6	79.2	107
210.3	191.9	62.1	107
215.0	336.8	66.4	107
217.3	210.8	81.6	106
217.6	215.7	81.3	106
220.0	39.4	61.2	110
220.3	43.3	60.7	110
220.6	58.1	62.2	110
222.1	79.0	56.0	110
222.6	112.9	56.3	110
229.9	291.7	53.9	107
242.4	277.8	82.4	107
243.5	220.6	77.0	107
244.1	229.0	84.9	107
246.1	244.0	73.8	107
247.2	177.6	59.4	105
247.5	176.7	63.4	105
248.6	212.7	82.8	105
251.7	79.3	69.6	107
252.1	57.9	70.1	105
252.5	53.9	70.0	105
253.3	26.2	69.6	107
257.2	11.6	70.3	109
258.1	42.3	75.1	109
259.6	26.5	70.2	107
260.1	27.9	73.3	107
262.1	257.4	60.9	107
263.7	108.8	70.5	107
265.0	10.8	68.1	107
268.1	9.4	73.6	106
268.2	8.1	71.9	106
268.9	338.3	70.7	106
270.5	11.5	79.5	107
271.3	23.2	69.0	107
280.1	244.2	60.5	106
280.5	220.2	76.7	106
281.3	209.8	64.2	106
282.5	257.4	50.8	110
282.9	236.4	51.4	110
285.6	180.7	46.3	109
285.8	190.9	47.3	109
286.4	171.0	61.9	107
287.1	206.7	65.9	107
291.2	208.9	43.9	109
291.3	206.0	44.5	109
295.3	258.5	57.5	107
296.5	28.8	51.3	107
298.0	199.4	64.2	107
299.2	251.0	43.9	109
299.6	225.0	36.1	109
303.2	189.4	65.8	105

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TABLE B-1
Well No. IT-W Discontinuities

Depth	Dip Azimuth	Dip Angle	Dip Code
303.4	193.9	68.1	105
303.7	197.9	66.6	107
305.2	55.4	25.2	107
331.7	249.5	60.2	107
332.6	246.9	67.6	106
334.2	269.8	71.4	107
344.3	212.0	84.5	107
345.0	221.5	84.2	107
345.9	241.1	84.6	107
348.1	338.4	46.0	107
348.2	343.7	46.6	107
352.1	334.5	34.3	109
352.2	343.7	33.3	109
366.8	332.9	72.5	107
367.1	340.0	74.8	107
367.8	3.5	72.7	107
370.5	0.6	47.1	107
372.5	269.5	69.0	110
373.9	282.9	70.6	110
381.3	313.3	42.0	109
382.4	331.4	62.0	109
383.4	328.0	48.4	109
383.4	264.1	75.0	107
388.9	255.0	59.0	107
389.8	274.6	67.8	106
390.9	287.0	65.7	110
392.2	269.2	68.4	110
392.8	343.6	62.6	106
393.7	320.9	63.2	106
397.4	232.6	77.7	107
403.3	160.2	10.4	109
409.4	244.8	55.3	109
413.2	238.0	60.7	107
414.2	229.3	57.1	107
417.3	211.5	84.2	105
420.0	222.3	56.9	106
423.2	219.1	69.1	110
423.7	205.3	70.3	110
425.2	197.0	72.0	110
425.6	189.4	71.2	110
427.4	205.3	72.3	109
429.4	204.6	71.4	110
429.7	198.5	70.5	110
439.8	323.2	50.4	105
440.2	329.0	50.4	105
441.4	48.4	72.8	106
441.9	57.7	71.5	106
442.7	221.6	81.2	106
443.7	229.9	84.4	106
444.7	229.0	85.0	106
447.1	241.4	86.5	106
449.9	240.6	79.9	107
451.1	258.6	75.1	107

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TABLE B-1
Well No. IT-W Discontinuities

Depth	Dip Azimuth	Dip Angle	Dip Code
451.8	225.2	72.2	107
452.9	5.7	70.6	109
454.1	269.5	73.0	110
455.2	251.7	75.8	110
456.2	260.2	75.1	110
457.7	255.3	81.0	110
458.4	255.7	80.7	110
459.1	243.5	79.8	110
459.9	229.8	78.7	110
463.6	21.4	76.2	107
466.1	17.3	72.9	107
467.1	216.9	78.2	110
469.1	251.6	76.7	110
469.8	259.1	76.2	110
472.0	253.3	57.8	105
472.2	247.7	61.4	105
474.1	264.6	71.6	110
474.7	277.9	73.4	110
477.6	187.1	85.0	107
478.5	189.5	85.3	106
480.9	314.3	82.9	106
481.1	313.4	83.3	106
481.9	280.6	75.7	110
482.1	281.5	74.9	110
482.4	293.9	74.8	110
482.6	291.5	73.4	110
482.9	288.9	71.0	110
484.8	284.5	77.9	110
485.9	256.3	71.0	110
486.2	262.2	71.3	109
488.7	284.0	64.5	109
489.0	296.4	63.8	110
489.3	312.2	46.5	107
489.5	323.9	32.2	107
496.5	333.5	52.1	107
497.5	42.1	61.6	107
499.6	292.3	52.8	110
500.1	304.0	47.3	110
500.9	271.2	58.2	110

TABLE B-2
Well No. RIZ-1B Discontinuities

Depth	Dip Azimuth	Dip Angle	Dip Code
53.3	199.4	79.2	105
55.8	13.9	60.3	109
57.3	3.4	51.0	107
58.1	145.4	58.9	107
59.6	35.5	85.1	109
60.8	349.4	58.0	105
61.3	336.7	22.1	105
62.0	173.9	32.2	105
62.5	171.2	32.9	105
68.8	191.3	79.4	109
72.9	282.5	81.3	105
73.9	166.2	74.1	105
76.0	251.6	63.7	107
79.5	315.6	83.3	106
80.0	15.3	89.8	105
84.8	274.9	81.9	107
97.8	84.7	54.7	107
102.7	43.1	86.7	105
112.3	269.8	66.7	107
113.9	163.1	65.7	105
114.1	255.7	80.0	105
116.9	241.4	74.2	105
117.0	257.3	74.5	105
122.9	23.4	73.1	106
123.5	6.4	71.7	106
124.7	9.2	80.7	106
129.7	114.7	74.9	106
131.0	16.1	81.8	107
135.6	208.3	64.7	105
136.6	213.8	72.9	105
137.3	44.0	74.0	105
138.5	193.1	77.0	107
138.9	204.2	77.5	107
139.5	199.6	76.3	105
140.5	200.4	76.1	105
140.9	192.7	73.0	105
145.0	197.4	81.5	109
147.0	239.2	79.0	106
155.9	286.9	69.5	106
156.8	201.4	86.9	105
162.3	48.8	68.5	106
163.0	261.8	69.2	107
171.0	233.3	69.3	105
172.2	244.5	81.8	109
173.1	291.6	68.3	105
173.3	271.1	67.7	105
174.6	299.4	57.3	106
175.6	249.2	70.4	106
176.5	282.0	82.9	106
178.1	310.3	66.2	107
179.2	295.0	67.4	107
183.2	357.0	76.4	105
185.2	218.4	82.7	105

TABLE B-2
Well No. RIZ-1B Discontinuities

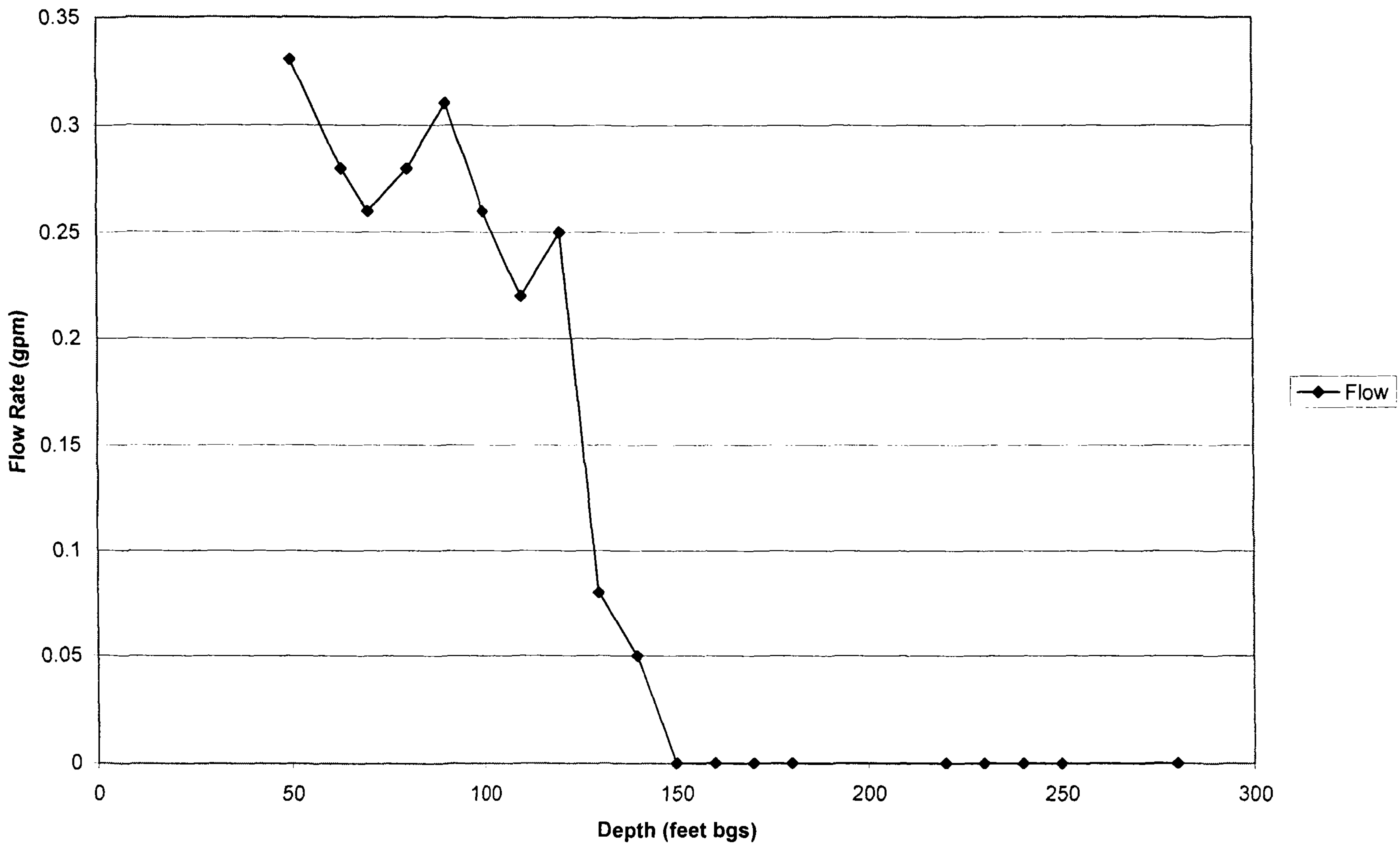
Depth	Dip Azimuth	Dip Angle	Dip Code
187.0	327.1	65.5	105
188.4	345.7	32.6	107
189.5	17.0	0.0	105
192.9	14.7	77.3	106
196.5	165.8	81.7	106
197.4	147.5	83.0	106
199.2	200.8	72.6	105
199.5	201.1	71.6	105
202.6	258.0	80.3	105
202.9	254.9	80.0	105
203.6	227.9	79.0	106
210.7	198.6	83.7	107
211.8	49.7	70.1	109
217.2	358.5	77.2	107
220.4	105.1	67.3	106
225.5	10.2	68.7	107
228.9	26.2	82.7	105
229.0	25.3	83.4	105
235.5	27.2	77.1	107
237.3	30.2	71.9	107
244.0	331.1	66.5	106
245.2	223.7	80.6	106
245.5	204.2	83.0	106
247.0	205.9	83.0	106
247.8	207.2	81.4	106
251.4	17.9	74.0	105
251.7	15.2	71.1	105
259.6	295.6	70.9	109
259.8	301.8	71.9	109
261.7	340.0	67.5	109
262.0	300.7	71.5	109
263.6	60.8	77.8	107
264.6	80.9	75.5	107
265.5	30.1	75.7	109
265.8	194.9	76.4	109
268.5	305.5	74.2	106
280.3	146.1	57.4	106
284.1	237.0	81.9	106
284.5	253.7	80.3	106
288.3	32.4	77.1	107
289.0	21.8	77.9	107
289.6	38.0	79.7	107
295.7	132.2	71.9	107
296.7	32.8	79.8	107
297.1	62.6	75.1	107
298.7	291.6	69.4	107

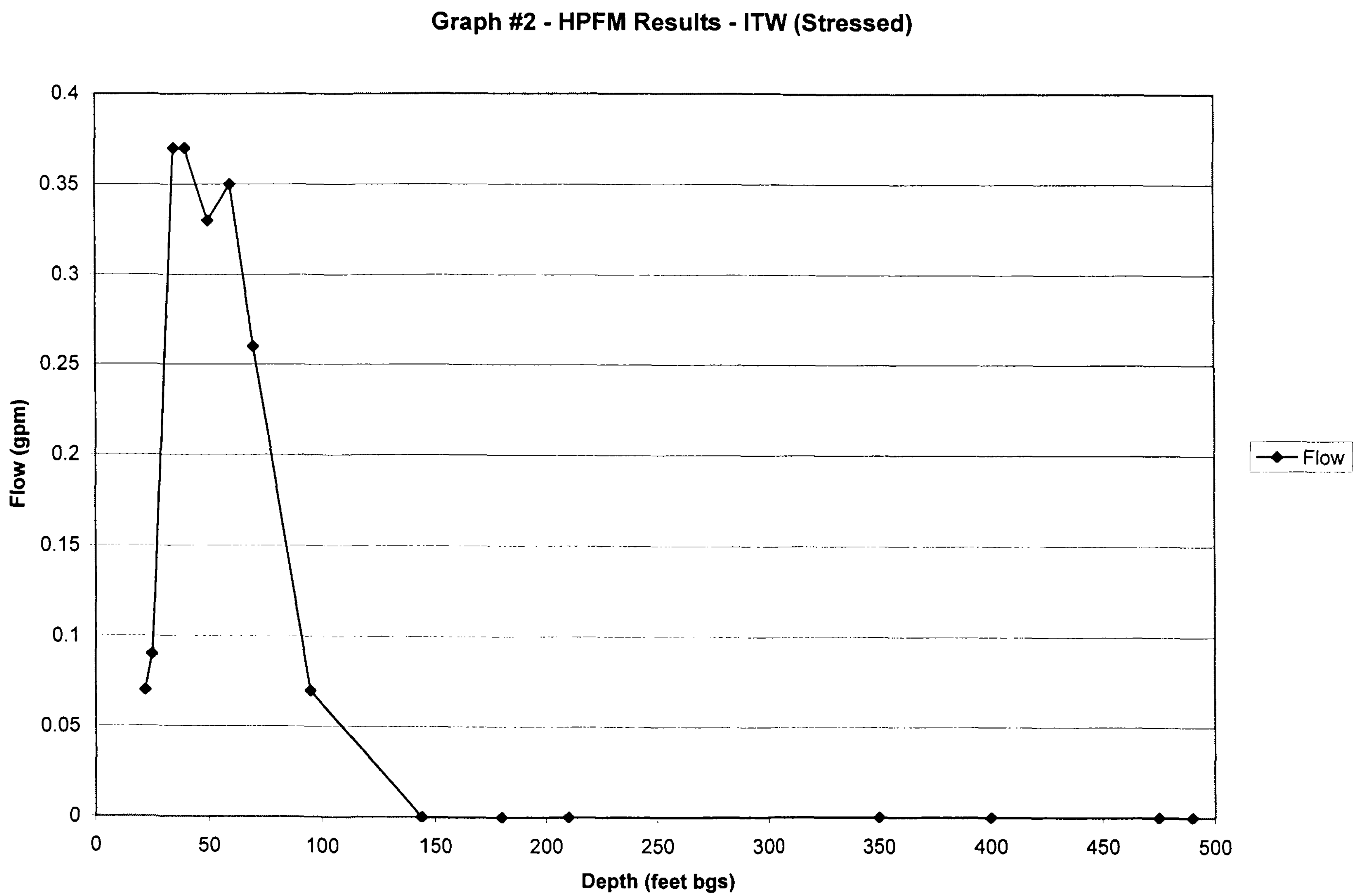
APPENDIX D

Appendix D

HPFM Graphs

Graph #1 - HPFM Readings - RIZ-1 (Stressed)




Graph #2 - HPFM Results - ITW (Stressed)
Flow (gpm)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
350
400
450
500
Depth (feet bgs)
Flow